Weerakoon, Ruwan, Kumar, Arun, & Desha, Cheryl
(2015)
Sustainability in post disaster road infrastructure recovery projects in Queensland, Australia. In
Barnes, Paul H. (Ed.)
The Proceedings of the 9th Annual International Conference of the International Institute for Infrastructure Renewal and Reconstruction. (8-10 July 2013), Queensland University of Technology, Brisbane, Australia, pp. 101-108.

SUSTAINABILITY IN POST DISASTER ROAD INFRASTRUCTURE RECOVERY PROJECTS IN QUEENSLAND, AUSTRALIA

Ruwan Weerakoon
Senior Infrastructure Planning Engineer
Rockhampton Regional Council
Queensland, Australia
Ruwan.Weerakoon@rrc.qld.gov.au

Prof: Arun Kumar and Dr Cheryl Desha
Queensland University of Technology
GPO Box 2434 Brisbane,
Queensland, Australia
arunkumarau@gmail.com
cheryl.desha@qut.edu.au

Abstract— between mid 2010 and early 2013, Queensland road related infrastructures were devastated by flood and cyclone related natural disasters. Responding to these recent events and in preparing for more regular and intense climate-change induced events in future, the Queensland Government is now reviewing how post-disaster road infrastructure recovery projects are planned and delivered. In particular, there is awareness that rebuilding such infrastructure need sustainable strategies across economic, environmental and social dimensions.
A comprehensive sustainability assessment framework for pre and post disaster situations can minimize negative impact on our communities, economy and environment. This research is underway to develop a comprehensive sustainability element frame work for post disaster management in road infrastructures in Queensland, Australia. Analyzing the implications of disruption to transport network and associated services is an important part of preparing local and regional responses to the impacts of natural disasters. This research can contribute to strategic planning, management leading to safe, efficient and integrated transport system that supports sustainable economic, social and environmental outcomes in Queensland.
Within this context, this paper provides an overview of the qualitative mixed-method research approach involving literature reviews and case studies to explore and evaluate a number of sustainability elements with a view to develop operational strategies for disaster recovery road projects.

***Keywords**-Sustainability Assessment Framework; Social Sustainability; Economic Sustainability; Environmental Sustainability; Post Disaster Road Recovery Projects.*

I. INTRODUCTION

The Queensland Government is dealing with the impacts of an unprecedented number of natural disasters, which have caused extensive damage to communities and key road, rail, ports and waterways infrastructure. Within mid 2010 and early 2011 for example Queensland transport related infrastructures were damaged by natural disasters with the estimated total damage exceeding $4 billion.

About 9,170 km of our Queensland state-controlled roads and more than one quarter of the total state-controlled network were damaged (TMR Intranet, no date). Three major ports were significantly affected and 29 per cent of our state rail network was impacted. In addition, 117 maritime navigational aids were damaged. This unprecedented scale of damage calls for a state-wide response, which is why the Main Roads Department has established the Transport Network Reconstruction (TNR) Program to reconstruct flood damaged transport network in three stages. Stage 1 rectification works were done to make the road trafficable and re-open to communities. Stage 2 recovery projects for repair works which will keep the road trafficable and safe for at least one year until proper restorations will be done with proper engineering designs. Stage 3 reconstruction program will manage all restoration works according to current engineering standard and will apply comprehensive engineering design to recover the transport network in Queensland.

Most of time engineering and asset management aspects are ignored when emergent disaster recovery projects are implemented due various constraints (time, resources and financial constraints) and political pressures. This kind of ignorance and irregularities in road asset recovery projects will bring negative internal and external effects for the community, economy and environment. This research focuses on proper asset management and engineering principles which should be followed and adopted in post disaster recovery projects to maximize sustainability and social benefits.

II. RESEARCH METHOD

For this research existing data related to disaster recovery projects is being collected from Department of Transport and Main Roads (DTMR) Queensland Government and will be analyzed. Any secondary research data can be structured to assess sustainability level of strategies that have been used for “disaster recovery road infrastructure projects”. In addition interviews are planned to gather information on sustainability elements which have been used for road reconstruction projects after disaster and develop a sustainability assessment element frame work for future post disaster projects.

III. SUSTAINABILITY

According to Oxford Advanced Learner’s Dictionary, (Hornby, 2005) sustainable means “involving the use of natural products and energy in a way that does not harm the environment”.

Always the environment dimension has been highlighted rather than social and economic dimensions in most definitions and comments on sustainability. The argument is society and economy are sub systems of environment and the economy is a sub system of the society as shown in the figure 1.

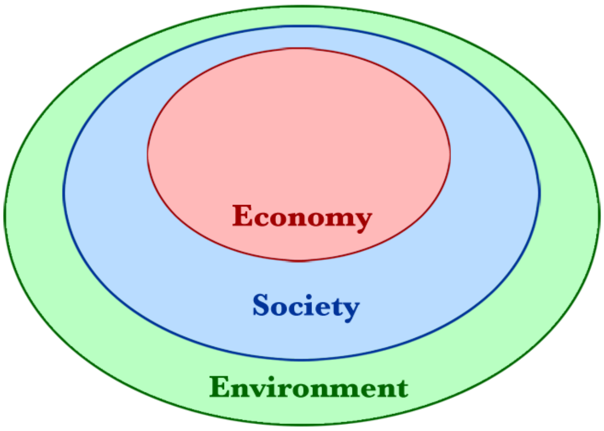

Figure 1. The relationship between the three pillars of sustainability suggesting that both economy and society are constrained by environmental limits (Source: Elkington, 1997)

The following discussion of Infrastructure Sustainability Assessment Categories mainly based on research conducted by Australian Green Infrastructure Council (AGIC 2011) and presents a brief summary of develop infrastructure project sustainability frameworks with the intent of delivering optimized outcomes:

The provided main themes are

1. Management & Governance
2. Using Resources
3. Emissions, Pollution and Waste
4. Ecology
5. People & Place
6. Innovation

These all mentioned themes can be allocated to triple bottom sustainability domains and can be used as criteria for the sustainability assessment. When we deliver road reconstruction projects, these six elements and their indicators can be accommodated to have a balance development.
Santos is one of the Australian leading gas producing and supplying company that operates in Australia and foreign countries. For Santos sustainability means supplying energy for the future and positive outcomes for shareholders, employees, business partners and the communities in which it operates (Santos Sustainability Report, 2010)

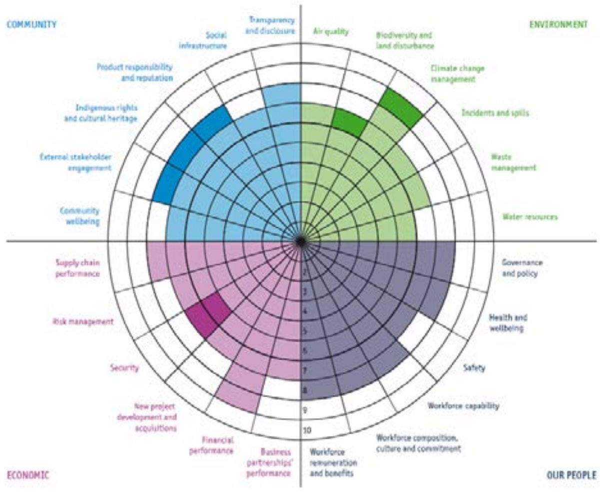

Figure 2. Sustainability Performance Scorecard (Santos Sustainability Report, 2010)

According to Santos annual report 2010, social sustainability has been divided to two parts as “our People” and “community” as shown in figure 2. Each sector in four domains has been scored for sustainability performance and performance compares with previous years with a defined benchmark and color coding. Even though Santos reports on sustainable energy supply, this type of performance scorecard can be used to represent or assess the level of sustainability of “infrastructure reconstruction projects”.

An overview of the process of developing environmental indicators for the transport sector is provided by Litman (2007; 2011). This report discusses how sustainability indicators can be applied to transport sector.
It describes factors to consider when selecting sustainable transportation indicators, identifies examples of indicators and indicator sets, and provides recommendations for selecting sustainable transport indicators for use in a particular situation.

Litman (2011) well describes and defines transport sustainability goals for all three domains and objectives and performance indicators for each goal. Also it shows the good governance and planning (integrated, comprehensive and inclusive planning) promotes and supports the sustainability of transport sector.

According to Austroads climate change research report (Impact of Climate Change on Road Performance-2010: Updating Climate Information for Australia, Austroads Pub. No. AP-R358/10, Sydney.), rainfall is a useful “climate series” to provide explanations of possible variations in pavement performance. For example, knowledge of future rainfall patterns can assist in the design of upgrades, or of pavement drainages, cross falls, selection of pavement material, surfacing, drainage and storm water structures etc. Climate condition, patterns and trends play a significant role in the road infrastructure performance and predictions of future climate conditions allowing road authorities to forecast climate change effects on their road infrastructure.

This Austroads research project could develop a finished software tool that efficiently extracts climate time series queries of historical data and simulated scenarios of climate change patterns. This data can be fed into deterioration models to compare past performance and identify future plausible scenarios of performance.

Climate change influences can be seen for the simple case of a pavement deteriorating due to time, or in the more complex multi-variable models which may include climate with traffic, some measure of structural strength, age, pavement type, etc. Another important research document has been published by Department of Climate Change and Energy Efficiency on climate change risks to coastal buildings and infrastructure. According to that report, by year 2100, nationally between 26,000-33,000km of roads are potentially at risk from the combined act of inundation and shoreline recession. It has predicted 1.1m sea level rise may happen by year 2100 and replacement value of Queensland roads will be around $10 billion. Future climate change trends, patterns and sea level rise needs to be considered and accommodated for transport planning and designing process.

According to ARRB research paper (Strategies for Sustainable Roads- 21st ARRB Conference May 2003- Tom Wilmot and Stuart Wilmot) there is a growing pressure from governments to be more frugal with the resources consumed for road construction.

Reduce or avoid consumption of input materials

Encourage reuse of material (especially non renewable resources)

Recycle material which cannot be reused

Reduce waste send to land fills

Insitu stabilization of soils and pavement materials is one option to assist in conserving these valuable resources.

Huge soil stock piles are available from open cut coal mines and most of excavated soil is suitable to use as structural layers in road pavement. Those stock piles are rehabilitated and re-vegetated and become man made mountains as shown below in figure 3.

Figure 3. Open Cut Coal Mines in Biloela, Queensland-Excavated Soil Stockpiles (Weerakoon, 2011)

Government organizations, coal mines and road authorities can have pre arranged agreement to use open cut mines’ gravel stock piles for road reconstruction activities in disaster situation. Required tests, environmental permits and accesses can be organized as a preparation before disasters happen and it will avoid any environmental and legislative conflicts.

Austroads Pavement Research Group (APRG) and Australian Asphalt Pavement Association (AAPA) has published some technical notes and research papers on reuse and recycling of road construction materials and reduce the non-renewable energy consumption.

We can minimize our demand, use and impacts on scarce resources such as water, gravel, rock, lime and non renewable energy products (Bitumen, Asphalt, Tar, Cutter, oil, Emulsions) and seek innovative solutions with more sustainable outcomes.

Some environmental friendly options for post disaster management of road projects are:

- Reduce the use of new materials
- Satisfy residual needs with reused and recycled material
- Material durability to fit asset life cycle (fit for purpose)
- Minimize inbuilt redundancy / minimal environmental impacts
- Recyclability / disposability in materials selection
- Include embedded energy aspects in life cycle evaluation
- Perpetual pavements
- Recycled asphalt pavements (RAP)
- Warm Mix Asphalt
- Emulsion based primes, primer seals & seals
- Use of waste materials (Crumb rubber –tires, Fly ash, glass, concrete)
- Bitumen stabilized pavements/ Insitu stabilization of pavement material
- Protection of scarce road surfacing gravel
- Modified binders lower risk for temperature rise and low odor binders
- Use waste engine oil as a pre coating agent for aggregate on road wearing course surface sealing

Above concepts are adopted from AAPA pavements training & advisory centre technical note on sustainability concepts in August 2011.

Transportation Research Board in USA (2004) explains current trends in transportation that could contribute to unsustainable conditions, including climate change, energy insecurity, congestion, noise pollution, and ecological impacts. The negative impacts of the transportation system include congestion; fatalities and injuries; noise, air, and water pollution; greenhouse gas emissions; diminishing energy resources; and biological and ecosystem damage. These negative effects can be minimized with integration sustainability into the transportation planning process.

IV. SUSTAINABILITY OF POST DISASTER ROAD RECOVERY PROJECTS

Planning, designing and construction of road infrastructure projects should be delivered according to economical, environmental and ecological sustainability aspects. Comprehensive designs to cater to future demands and applying current engineering standards for post disaster recovery projects are challenges with limited reconstruction time and financial constraints. Pressures to reopen the damaged road network with temporary recovery strategies are inevitable with the political pressures and social demands.

The concept of sustainable development is faced with the challenge to combine ecological, economic and social goals into one integrated approach by minimizing negative impacts and making the best and most equitable use of resources.

Proper engineering designs and construction methodologies do play a vital role in achieving all three sustainability domains.

Figure 4. Flood damaged roads in Central West Region,Queensland, Australia in early 2011 (DTMR, 2011)

The concept of Sustainable Development was first put forward by the OECD World Commission on Environment and Development (the "Brundtland Commission" 1987 "Our Common Future") and defined as: *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

In promoting sustainable development, the challenge for policy-makers is to reconcile three objectives (triple bottom line):

Securing higher standards of living through economic development;

Protecting and enhancing the environment;

Ensuring an equitable distribution of the benefits within the present generation and between present and future generations.

In the past, however, not many of these post disaster reconstructions had an entire sustainability-oriented evaluation conducted. Insufficient financial and time resources reserved for such a task, lack of information and data availability, missing expertise and often a low level of awareness within authorities and the public, are some of the reasons.

After 2010 flood damages to Queensland Road Network, Emergency Management Queensland was under pressure to reconstruct the road network according to current engineering standard rather than rectify the damages to bring the road to existing condition. Sustainability in infrastructure engineering and asset management empower triple bottom domains and is the integrating dimension of infrastructure sustainability.

A framework (Table 1 below) has been developed to assess the sustainability in post disaster road recovery projects and it will be expanded with more categories and subcategories with indicators.

TABLE I. SUSTAINABILITY ASSESSMENT FRAMEWORK FOR POST DISASTER ROAD RECOVERY PROJECTS

Social Sustainability Dimension	
Category	***Description***
Acess for the essential social services	Community access to education, health and other basic services provided by the government and private sector
Sanitation, health and safety	Clean drinking water and food supply after the disaster. Medicines, medical treatments and access to safe shelters.
Community consultation	Community involvement for post disaster recovery projects in different stages at different levels
Community development and empowerment	Develop damaged community infrastructure through their involvement and enhance their financial capacity and empower them through their participation
Amenity and land use	Improved amenity and acquisition of lands for reconstruction and flood immunity
Economic Sustainability Dimension	
Category	***Description***
Efficient transport operations	Re open the road network and provide efficient transport system for agriculture, coal, gas and other industries after the disaster to rebuild the economy.
Value for money	Benefit cost analysis and multi criteria analysis for post disaster recovery projects to acheive maximum benefits for money spent.
Creation of employment opportunities for vulnerable groups	Generation of livelihoods for vulnerable groups and disaster affected communities to enhance their financial capacity.
Environmental Sustainability Dimension	
Category	***Description***
Debris removing and proper disposal	Remove all debris from road corridors and adopt a waste management hierarchy of waste avoidance, waste reuse, waste recycling, energy recovery from waste and waste disposal
Pollution control through reconstruction	Avoid or minimize adverse impacts to soil, water and air through the reconstruction projects.
Reuse and recycle of material	Minimize demand, use and impact on scarce resources such as water, gravel, rock, lime and non renewable energy products
Biodiversity protection	Protect bio diversity and habitats for future generations and sustainable eco system during the reconstruction process.
Engineering Design and Good Governance (This element reinforces and enforces the triple bottom sustainability domains)	
Category	***Description***
Improved flood immunity	Design and rebuild all possible road related infrastructure with improved flood immunity with proper engineering designs.
Build in to current engineering and safety standards	Rebuild the structures according to current safety and engineering standards.
Innovation and reengineering	Seek innovative engineering solutions with more sustainable outcomes
Efficient use of material and resources	Efficient and effective use of available resources and fund to rebuild the damaged road related infrastructure.
Good Governance	Policies, procedures, legislations,enforcement and functional structure.

V. TRANSPORT NETWORK RECONSTRUCTION (TNR) PROGRAM IN QUEENSLAND

Department of Transport and Main Roads (TMR) vision for the TNR Program is ‘Restoring our flood-damaged transport networks in a safe, timely and efficient manner to reconnect, rebuild and improve Queensland’. TNRP is the program created by Queensland Government TMR to respond and reconstruct the flood damaged road network and TNRP data and project status reports will be used to assess the sustainability of delivered outcomes. It will be the main data source for the research study.

There are seven objectives for the TNR Program:

Coordination across lines of reconstruction: Support the economic recovery of industry and communities through timely completion and prioritization of reconstruction work.

Resilience: Deliver a transport network with greater resilience by following the TNR Program Guidelines for Reconstruction.

Immunity: Identify asset enhancement opportunities for infrastructure requiring reconstruction, focusing on safety and immunity.

Value for money: Achieve demonstrated value for money for the Commonwealth and the people of Queensland in delivering the transport reconstruction program.

Timely completion: Complete the program and make use of available funding within our stakeholder’s timeframes.

Communication and engagement: Regularly engage with stakeholders including communities, industry, Emergency Management Queensland and the Queensland Reconstruction Authority to inform our reconstruction priorities and business.

Transition back to normal business: Maintain and enhance TMR's reputation with stakeholders and transfer information, systems and knowledge into the department’s structures.
The Transport Network Reconstruction Program objectives align with the Queensland Government’s *Towards Q2: Tomorrow’s Queensland*, Queensland Reconstruction Authority strategic objectives and strategic milestones.

VI. CONCLUSION

It is essential that sustainability should be an integral part of road infrastructure recovery projects. This study captures the existing disaster recovery strategies that have been implementing to rebuild the road infrastructures damaged by Queensland Flood Disasters from 2010 to 2013 January and assesses the sustainability impact which has environmental, economic, and social dimensions. It develops a framework for improvements with a view to optimize the sustainability of disaster recovery road projects that will deliver services to Queensland communities in Australia.

REFERENCES

[1] Austroads Pavement Research Group (1999) Technical Note 10, Austroads.

[2] Australian Asphalt Pavement Association (2011) *AAPA Pavements Training & Advisory Centre- Sustainability Concepts*, August 2011.

[3] Austroads (2010). *Impact of Climate Change on Road Performance: Updating Climate Information for Australia*, Austroads Pub. No. AP-R358/10, Sydney.

[4] Australian Green Infrastructure Council (2011) *Fact Sheet 2*, AGIC Publications.

[5] Department of Climate Change and Energy Efficiency (2011) *Climate Change Risks to Coastal Buildings and Infrastructure,* Australian Federal Department of Climate Change and Energy Efficiency.

[6] Department of Transport and Main Roads (2011) *Transport Network Reconstruction Program*. Queensland Department of Transport and Main Roads

[7] Litman, T. (2011) *Well Measured: Developing Indicators for Sustainable and Livable Transport Planning,* Victoria Transport Policy Institute, 8 June 2011.

[8] Litman, T. (2007) "Developing Indicators For Comprehensive And Sustainable Transport Planning," *Transportation Research Record 2017,* Transportation Research Board, pp 10-15.

[9] Hornby, A.S (2005) Oxford Advanced Learner's Dictionary, 7th Edition. Definition of Sustainability PP1548

[10] Queensland Department of the Premier and Cabinet (2008) *Toward Q2 Tomorrow's Queensland Policy*

[11] Santos (2010) Santos Annual Report: Leading Gas Producers and Suppliers Web,

[12] Wilmot. T, and Wilmot, S. (2003) Strategies for Sustainable Roads- 21st ARRB Conference, May 2003.

[13] Transportation Research Board (2004) "Integrating Sustainability into the Transportation Planning Process Baltimore", in Conference Proceedings 37, Maryland July 11–13, 2004.

BIOGRAPHIES

Ruwan Weerakoon (B.Eng, M.Eng, MIEAust, CPEng, RPEQ)
Ruwan Weerakoon has over 13 years international and local experience in road and infrastructure construction, management and planning in Singapore, Sri Lanka, Afghanistan, South Sudan and Australia.
He has qualifications in civil engineering and successfully completed Master of Infrastructure Engineering and Management at University of Monash in 2010. From 2004 to 2008 he has worked for United Nations post disaster reconstruction projects in Afghanistan, Tsunami Recovery Projects in Sri Lanka and South Sudan as a consultant engineer and project manager.
He joined Department of Transport and Main Roads in 2008 worked five years as a project manager/ principal engineer in Fitzroy Region, Central West Region and South West Region in Queensland. Also he managed and delivered flood damaged recovery road projects in Fitzroy Region after 2010 flood event. Now he works for Rockhampton Regional Council as a senior engineer for infrastructure planning projects.
Ruwan is a PhD student at Queensland University of Technology and his research is to identify the gap of sustainability requirements of post disaster road recovery projects and contribute to develop sustainable disaster recovery strategies with his knowledge, experience and skills he has gained through his higher studies, research and professional career life.
E: Ruwan.Weerakoon@rrc.qld.gov.au

Professor Arun Kumar
BTech (IITD), MSCE, PhD (Purdue), FIEAust, CPEng, GDM, LM IRC, FISEAM
Professor of Infrastructure management
Queensland University of Technology
Emeritus Professor RMIT University

Professor Arun Kumar has over 40 years experience as a civil/ roads engineer in construction, consulting, research and academia. His areas of expertise include: infrastructure management, sustainability, project management, institutional strengthening and capacity building. He has worked with Indiana Dept of Highways, USA; Ministry of Surface Transport India, VicRoads, SKM, RMIT and QUT

He has written over 170 papers in national and international journals and conferences; has been an invited speaker in several countries; has been on the international committees and has chaired at the international conferences. His international experience includes the countries of: Australia, China, India, USA, and Southeast Asia.

Professor Kumar is a consultant to the World Bank on infrastructure management, institutional strengthening and capacity building; and is Professor Emeritus, RMIT University, Melbourne, Australia. He is a Fellow of the Institution of Engineers Australia since 1992; Vice President, Australia and NZ: International Society for Maintenance and Rehabilitation of Transport infrastructures; Fellow of the International Society of Engineering Asset management.

E: arunkumarau@gmail.com
M: +61(0)411040481

Dr Cheryl Desha
PhD, Bachelor of Engineering

Lecturer in Sustainable Development
Queensland University of Technology

Dr Cheryl Desha is a lecturer in sustainable development at the Faculty of Built Environment and Engineering, and a Research Principal at The Natural Edge Project (TNEP), a non-profit partnership on research, education and strategy for innovation for sustainable prosperity.

Since 2003, Dr Desha has been the co-investigator on over 1.7 million dollars of research grants, which will increase to 3 million by 2012. Since 2005, and including works in development for 2010, she has achieved 11.55 HERDC publication points, an average of 2.31 points per year.

Dr Desha's career goal is to facilitate sustainable development by empowering society with emerging language, knowledge and skills related to achieving sustainable solutions. In particular she is committed to building capacity for sustainable development, including topics such as energy efficiency, biomimicry, whole system design and biophilic urbanism. Together with the team from TNEP, Dr Desha has developed a range of projects focused on education and training for sustainable development, including working with universities, professional bodies, government agencies, companies, and schools and touring international keynote speakers.

E: cheryl.desha@qut.edu.au